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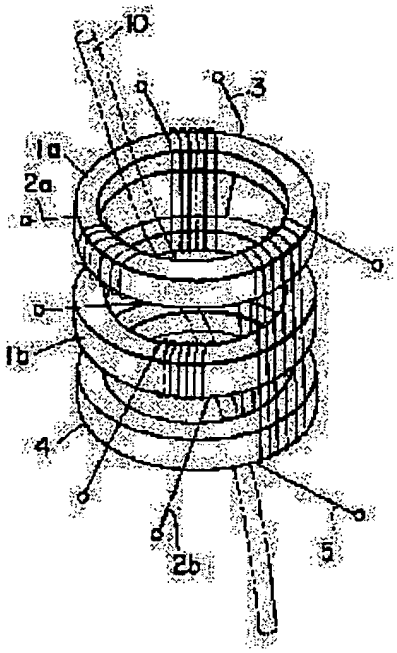
(54) ELECTRIC CURRENT SENSOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an electric current sensor which is effective as a sensor for managing amounts of charging and discharging of a battery in an electric car or the like, can measure a wide range of direct current from small current to large current and can measure alternating current flowing through a conductor to be detected in the superimposed state.

SOLUTION: Exciting coils 2a and 2b are wound and arranged at direct current component detection cores 1a and 1b made of a ring-shaped soft magnetic material, a direct current component detection coil 3 is wound and arranged over this pair of direct current component detection cores, and an alternating current component detection core 4 made of a ring-shaped soft magnetic material is arranged in parallel. A feed back coil 5 is wound and arranged over the above pair of direct current component detection cores 1a and 1b and the alternating current component detection core 4, and a conductor to be detected 10 is pierced and arranged inside the direct current component detection cores 1a and 1b and the alternating current component detection core 4.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is [both] effective as an administrative sensor of the application which needs to measure the output characteristics in the condition of having been superimposed on those currents, for example, the charge of the dc-battery in an electric vehicle, and the amount of discharge, when a direct current and alternating current flow in a detected lead wire, and it relates to the current sensor in which an amperometry wide range [from a small current to a high current] moreover comparatively is possible.
[0002]
[Description of the Prior Art] Recently, by the administrative sensor of the ** and the amount of discharge of the dc-battery in an electric vehicle, when it is required that the condition of a current of flowing the inside of a detected lead wire should be detected as it is, namely, both a direct current and alternating current flow in one detected lead wire, it is required that the output characteristics (the amount of currents per time amount) in the condition of having been superimposed on those currents should be measured.
[0003] From the former, various sensors which measure independently the direct current or alternating current which flows the inside of a detected lead wire are proposed, and the applicant for this patent also proposed the direct-current sensor of the high sensitivity which has the ability to detect which is comparatively easy structure and was excellent in linearity to the current change (for example, about 0.2A-20A) from a minute current to a comparatively big current (JP,7-128373,A).
[0004] In the easiest configuration that carried out winding arrangement of an exiting coil and the sensing coil at the shape of toroidal one at the core which this direct-current sensor becomes from an annular soft magnetic material When the exciting current of the shape of a chopping sea which makes an exiting coil generate the magnetic field exceeding the coercive force of a core is passed, Paying attention to the sense of magnetic flux incore being reversed, the timing of this reversal is detected on the electrical potential difference of the shape of a pulse generated in a sensing coil. It consists of a configuration of detecting the absolute value of the direct current which flows to this detected lead wire, by comparing these pulse separations corresponding to change of the absolute value of the direct current which flows to a detected lead wire by which penetration arrangement is carried out incore.
[0005]
[Problem(s) to be Solved by the Invention] although the direct current sensor which consist of the above-mentioned configuration which the applicant for this patent proposed previously be comparatively easy structure and it be the structure have the ability to detect which be excellent in linearity also to a comparatively wide range current change , by the administrative sensor of the ** and the amount of discharge of the dc-battery in an electric vehicle , it be require that the very large range (about **400A) from the small current at the time of dc-battery charge to the high current at the time of transit should be measure with a sufficient precision .
[0006] However, one side of the pulse separation which an output pulse is not obtained in the time

amount region which a magnetic field change incore was lost when it was superimposed on the magnetic field incore generated according to the direct current which flows to the magnetic field incore generated according to a chopping sea-like exciting current and a detected lead wire and incore was saturated by these magnetic fields, and has been saturated as a result, but are generated in a crest side [of a chopping sea] or trough side becomes very small, and measuring [of high sensitivity] becomes difficult. When the direct current which flows to a detected lead wire exceeded about 20A according to the experiment of an applicant for this patent, implementation of the amperometry made into the object by one [said] pulse separation serving as zero substantially was difficult.

[0007] This invention aims at the proposal of a current sensor which makes measurable where the alternating current which flows the inside of a detected lead wire is also superimposed especially, without spoiling the original advantage which the direct-current sensor which consists of a configuration which proposes in view of the above actual condition, and the applicant for this patent proposed previously has while it is effective as an administrative sensor of the ** and the amount of discharge of the dc-battery in an electric vehicle etc. and measurement of a wide range direct current from a small current to a high current is possible for it.

[0008]

[Means for Solving the Problem] While arranging effectively the direct-current sensor which consists of a configuration which the applicant for this patent proposed previously as a result of considering various configurations, in order that an artificer may attain the above-mentioned object, and the direct-current sensor of a couple with the same fundamental configuration Measurement of the direct current stabilized by using a feedback coil even when it was wide range was attained, and it checked further that the effectiveness beyond anticipation was acquired by adopting the easiest configuration using the annular soft magnetic material also as an alternating current sensor.

[0009] Namely, the dc-component detection core which consists of an annular soft magnetic material of a couple with which this invention carries out winding arrangement of the exiting coil at the shape of toroidal one, The dc-component sensing coil which carries out winding arrangement ranging over the dc-component detection core of this couple, It has the feedback coil which carries out winding arrangement ranging over the alternating current component detection core which consists of an annular soft magnetic material, and the dc-component detection core of said couple and an alternating current component detection core. While carrying out penetration arrangement of the detected lead wire with which a direct current and alternating current flow inside said dc-component detection core and an alternating current component detection core Each exiting coil which carries out winding arrangement is connected to the dc-component detection core of said couple so that it may become an opposite phase in electromagnetism. By passing the exciting current of the shape of a chopping sea which generates the magnetic field which exceeds the coercive force of this core to each dc-component detection incore While measuring the force current to the feedback coil which makes zero substantially the output of a dc-component sensing coil based on the magnetic flux to generate and the magnetic flux which generates a detected lead wire according to the flowing direct current By measuring the alternating current generated in a feedback coil based on the magnetic flux which generates a detected lead wire in an annular soft magnetic material by the flowing alternating current, it is the current sensor characterized by measuring the direct current and alternating current which flow a detected lead wire.

[0010] Furthermore, in the above-mentioned configuration, the current sensor characterized by the alternating current component detection core which consists of an annular soft magnetic material consisting of a configuration which carried out couple arrangement at the ends side of this dc-component detection core through the dc-component detection core which consists of an annular soft magnetic material of a couple is proposed collectively.

[0011] Moreover, the current sensor characterized by consisting of a configuration which has arranged the dc-component sensing coil which carries out winding arrangement ranging over the dc-component detection core which consists of an annular soft magnetic material of the couple which carries out winding arrangement of the exiting coil at the shape of toroidal one as a more desirable configuration, and the dc-component detection core of this couple in a shielding case is also proposed collectively.

[0012]
[Embodiment of the Invention] In the current sensor of this invention, the dc-component detection core which consists of an annular soft magnetic material of a couple is not limited to it being the so-called shape of a ring like a graphic display, and can carry out penetration arrangement of the detected lead wire with which a direct current and alternating current flow to that inside, and the shape of a rectangle frame etc. can also be used for it in consideration of the workability of coil coils, such as workability and an exiting coil, etc. that what is necessary is just to connect so that this soft magnetic material may constitute a closed circuit in electromagnetism.
[0013] selecting in consideration of the magnetic properties according to the detection sensitivity which the soft magnetic material which constitutes a dc-component detection core has a fundamentally desirable ingredient with small coercive force with high permeability, and is demanded, workability, etc. -- required -- a nickel-Fe system alloy (permalloy), a silicon steel plate, amorphous one, and electromagnetism -- the activity of well-known elasticity magnetism alloy ingredients, such as soft iron, is desirable. In addition, the dc-component detection core of a couple needs to have the same magnetic properties, i.e., the same construction material, a configuration, and a dimension to realize measurement of high degree of accuracy.
[0014] As for the alternating current component detection core which consists of an annular soft magnetic material, it is desirable for alternating current magnetic properties to select a good ingredient, and it is desirable to use the layered product of a Mn-Zn system soft ferrite, a nickel-Zn system soft ferrite, and the above-mentioned elasticity magnetism alloy ingredient. Moreover, suppose that it is the same for realizing measurement which is wound around a dc-component detection core and whose super-magnetism (ampere turn) of an exiting coil is high degree of accuracy respectively.
[0015] The working principle of the current sensor of this invention is explained based on drawing 1 and drawing 2 . In drawing 1 , 1a and 1b are dc-component detection cores which consist of elasticity magnetism alloy ingredients, such as a nickel-Fe system alloy, and 2a and 2b are exiting coils by which winding arrangement is carried out respectively at the dc-component detection cores 1a and 1b. In addition, as exiting coil 2a and 2b are mentioned later, they are connected so that each may become an opposite phase in electromagnetism. 3 is a dc-component sensing coil which carries out winding arrangement ranging over the dc-component detection core of a up Norikazu pair.
[0016] Furthermore, in drawing 1 , 4 is an alternating current component detection core which consists of an annular soft magnetic material, and winding arrangement of the feedback coil 5 is carried out ranging over the dc-component detection cores 1a and 1b of said couple, and this alternating current component detection core 4. Thus, after constituting, penetration arrangement of the detected lead wire 10 with which a direct current and alternating current flow inside said dc-component detection cores 1a and 1b and the alternating current component detection core 4 is carried out.
[0017] In such a configuration, the principle of operation which measures the direct current I which flows the detected lead wire 10 is explained. For example, if the exciting current of the shape of a chopping sea which generates the magnetic field which exceeds the coercive force of dc-component detection core 1a to exiting coil 2a by which winding arrangement is carried out at dc-component detection core 1a in the condition that a direct current I is not flowing to the detected lead wire 10 passes, in dc-component detection core 1a, the magnetic flux shown as the continuous line of drawing 2 A occurs, and the wave-like output shown in the dc-component sensing coil 3 as the continuous line of drawing 2 B based on the flux reversal will be detected. That is, the width-of-face dimension of an output wave becomes the same (b1=b2).
[0018] It is superimposed on the magnetic field which will be generated according to this direct current I in dc-component detection core 1a if a direct current I flows to the detected lead wire 10, and the magnetic field generated according to the exciting current of the shape of a chopping sea impressed to said exiting coil 2a, it shifts to an alternate long and short dash line location, the magnetic flux shown with the broken line of drawing 2 A occurs here, and the wave-like output shown in the dc-component sensing coil 3 with the broken line of drawing 2 C based on the flux reversal is detected. That is, a width-of-face dimension serves as an output wave which is different by + and - side (c1<c2).

[0019] By being based on [redacted] output wave, and integrating with and calculating the output wave by the side of +, and the output wave by the side of -, the amount of currents can be calculated with the sense (polarity) of the direct current I which flows the detected lead wire 10.
[0020] The same measurement as the above can be performed also in the combination of dc-component detection core 1b and exiting coil 2b. In order to measure the current which flows to the detected lead wire 10 to high sensitivity, it is necessary to enlarge amplification degree (gain) beforehand but, and since the output wave based on [do not stop and] exiting coil 2a or the exciting current from 2b which uses these independently is outputted to a sensing coil 3, it is saturated only with the output and amplification degree cannot be enlarged.
[0021] the applicant for this patent checked that it was cancelable by connecting so that the above-mentioned problem may be set to exiting coil 2a of these each and he may set 2b an opposite phase in electromagnetism. That is, when the current which flows to the detection lead wire 10 is zero, it becomes possible by making an output signal into zero to enlarge amplification degree. In addition, means, such as making into an opposite phase the exciting current of the shape of a chopping sea which makes an opposite direction mutually exiting coil 2a and the direction of winding of 2b, or is impressed, are employable. Therefore, in the condition that a direct current I is not flowing to the detected lead wire 10, a reverse output wave will completely be outputted to + [in drawing 2 B], and - side, and if these are doubled, the output from a sensing coil will serve as zero substantially.
[0022] Furthermore, if it connects so that it may become an opposite phase in electromagnetism to exiting coil 2a about exiting coil 2b in the condition that a direct current I is flowing to the above-mentioned detected lead wire 10, if dc-component detection core 1b and exiting coil 2b are explained, the magnetic flux shown with the two-dot chain line of drawing 2 A in dc-component detection core 1b will occur, and the wave-like output shown in the dc-component sensing coil 3 according to the two-dot chain line of drawing 2 D based on the flux reversal will be detected. That is, a width-of-face dimension serves as an output wave which is different by + and - side (d1<d2 however c1=d1, c2=d2).
[0023] Therefore, the sum with the wave-like output shown in the dc-component sensing coil 3 according to the wave-like output shown with the broken line of drawing 2 C and the two-dot chain line of drawing 2 D will be outputted, and the wave-like output shown as the continuous line of drawing 2 E is obtained as a result. The sense (polarity) of the direct current I which flows the detected lead wire 10 by whether this output wave is in + side or it is in - side can be checked, and the amount of currents of the direct current I which flows the detected lead wire 10 can be checked by asking for namely, integrating with the area of this output wave electrically.
[0024] However, it is superimposed on the magnetic field incore generated according to a chopping sea-like exciting current as the conventional example also explained, when the absolute value of the direct current I which flows the detected lead wire 10 became large, and the magnetic field incore generated according to the direct current which flows to a detected lead wire, and incore cannot be saturated by these magnetic fields, the magnetic field change by incore cannot be lost, and the above output waves cannot be acquired as a result, but the measurement made into the object becomes difficult.
[0025] An applicant for this patent until the output detected with a sensing coil 3 with the further above-mentioned configuration becomes zero A predetermined direct current i in the feedback coil 5 so that the magnetic flux of the direction which negates this magnetic flux until the magnetic flux generated in dc-component detection core 1a and 1b based on the direct current I which flows the detected lead wire 10 becomes zero may be generated Namely, a sink, What (i=I/Nf Nf: the number of ** of the feedback coil 5) the absolute value of the direct current I which flows the detected lead wire 10 as a result can be known for by measuring the current value was checked.
[0026] Since the magnetic flux generated in dc-component detection core 1a and 1b by using the above-mentioned feedback coil 5 measures in the state of zero substantially, the field by which the magnetic property of the dc-component detection cores 1a and 1b was stabilized most will be used, and measurement which was excellent in linearity in the large area from a small current to a high current can be realized.
[0027] Also when having measured the direct current I which flows the detected lead wire 10 explained

above, alternating current flowing to the detected lead wire 10. However, even if alternating current is flowing, based on the magnetic flux in each dc-component detection core 1a generated by this alternating current, dc-component detection core 1b, and the alternating current component detection core 4, electromotive force occurs in the feedback coil 5, and a predetermined current flows. Since this current generates the magnetic flux of the direction which negates the magnetic flux in said each [of a dc component] detection core 1a, dc-component detection core 1b, and the alternating current component detection core 4, substantially, respectively, magnetic flux incore is canceled and does not affect measurement of the above-mentioned direct current I. However, in order to acquire such operation effectiveness, it is desirable to usually wind the feedback coil 5 of several 1000 or more ******s.
[0028] Moreover, a current wave form can be searched for by measuring the alternating current which generates the detected lead wire 10 in the feedback coil 5 about the flowing alternating current based on the magnetic flux (alternation) generated in an annular soft magnetic material by this alternating current.

[0029] In addition, as explained previously, in order that the feedback coil 5 may measure the direct current I which flows the detected lead wire 10, although measurement of the above-mentioned alternating current with a sink will also be carried out, the direct-current I itself calculates a predetermined direct current (feedback current) from the value of feedback current, and this feedback current does not do effect at all, in order to only shift a zero point to alternating current and to measure the current wave form of alternating current. Therefore, it becomes possible by observing the output wave of the feedback coil 5 to measure many properties in the condition that the detected lead wire 10 was superimposed on alternating current with the flowing direct current.
[0030] Although the configuration of the dc-component detection cores 1a and 1b which the alternating current component detection core 4 which consists of an annular soft magnetic material turns into from the annular soft magnetic material of a couple in drawing 1 arranged only to one end on the other hand was shown Through the dc-component detection cores 1a and 1b which consist of an annular soft magnetic material of a couple especially by carrying out couple arrangement at the ends side of this dc-component detection core 4 The measurement which could reduce the error by the unbalance of the magnetic flux generated when the detected lead wire 10 and the feedback coil 5 which penetrate incore [these] are not arranged at parallel, and was stabilized further is realizable.
[0031] Moreover, arrangement of the alternating current component detection core 4 which consists of an annular soft magnetic material contributes to it not only enabling measurement of the alternating current which flows the detected lead wire 10, but having the function as a current transformer (CT) with this so-called, same core 4, improving frequency characteristics, and improving the speed of response as the whole current sensor.
[0032] Furthermore, the dc-component detection cores 1a and 1b which consist exiting coil 2a and 2b toroidal [-like] of an annular soft magnetic material of the couple which carries out winding arrangement in the above-mentioned configuration, By arranging the dc-component sensing coil 3 which carries out winding arrangement ranging over the dc-component detection cores 1a and 1b of this couple in a shielding case The effect by magnetic fields other than the magnetic field which negates the magnetic field generated in dc-component detection core 1a and 1b based on the direct current I which flows the original detected lead wire 10 generated with the feedback coil 5 can be reduced, and it becomes a desirable configuration realizing measurement of high degree of accuracy.
[0033]
[Example] In order to check this effect of the invention, the current sensor shown in drawing 1 was created. The dc-component detection cores 1a and 1b pierced the permalloy C with a thickness of 0.35mm (78%nickel-5%Mo-4%Cu-balFe) in the outer diameter of 45mm, and bore of 33mm, respectively, and performed predetermined heat treatment.
[0034] Furthermore, the electric insulation was secured to these dc-component detection cores 1a and 1b, and winding arrangement of exiting coil 2a, 2b, and the sensing coil 3 was carried out. Furthermore, after securing the electric insulation with the dc-component detection cores 1a and 1b and having, arranged the alternating current component detection core 4 of a Mn-Zn system soft ferrite which

consists of 5mm in the outer diameter of 45mm, the bore of 33mm, and thickness to one end on the other hand, as the dc-component detection cores 1a and 1b and an alternating current component detection core were straddled like a graphic display, winding arrangement of the feedback coil 5 was carried out.

[0035] In addition, exiting coil 2a and 2b consist of a configuration in which HORUMARU line 1000 turn winding with an outer diameter of 0.12mm and a sensing coil 3 wound the HORUMARU line with an outer diameter of 0.12mm, and 1000 turn winding and the feedback coil 5 wound 4000 ******s of HORUMARU lines with an outer diameter of 3.0mm, respectively.

[0036] While carrying out penetration arrangement of the detected lead wire 10 which consists of a vinyl coat with an outer diameter of 16mm inside the dc-component detection cores 1a and 1b and the alternating current component detection core 4 Previously, exiting coil 2a which carried out winding arrangement independently, and 2b were connected to the dc-component detection cores 1a and 1b so that it might become an opposite phase in electromagnetism by the predetermined approach, the predetermined electronic circuitry was connected for these exiting coils, the sensing coil, and the feedback coil, and the current sensor of this invention was completed. In addition, the exciting current of the shape of a chopping sea impressed to exiting coil 2a and 2b was set to f= 4kHz and Ip=**15mA.

[0037] Here, close and output characteristics in the current sensor of this invention at the time of passing a direct current in the range of **400A are shown in the detected lead wire 10 at drawing 3 . It was wide range than drawing 3 , and has checked that the property of a linear was acquired.

[0038] Drawing 4 shows frequency characteristics [in / for predetermined alternating current / 500mArms and the current sensor of this invention when passing 20 Arms] to the detected lead wire 10 10 Arms 5 Arms 1 Arms, among drawing, in 1Arms and c, 5Arms(es) and d show 10Arms(es) and, as for a, e shows [500mArms(es) and b] 20Arms(es). From drawing 4 , it has checked that there was little output fluctuation also by fluctuation of a frequency.

[0039] Drawing 5 B shows the electrical potential difference of the feedback coil outgoing end when passing the shape of a rectangle which consists of a predetermined frequency (1kHz, 1 Ap-p) to the detected lead wire 10. It has checked that the same change as the current passed from drawing 5 to a detected lead wire appeared as feedback coil output voltage. Therefore, according to the current on which a detected lead wire flows, it became clear that the same output appears with sufficient flattery nature.

[0040]

[Effect of the Invention] As shown above, it sets to the current sensor of this invention. With the direct-current sensor which consists of a configuration which the applicant for this patent proposed previously By arranging effectively an alternating current component detection core and a feedback coil Have the ability to detect which is comparatively easy structure and was excellent in linearity also to a wide range current change. That is, it is the structure which made measurable even the range of about **0.1A-400A, and offer of a current sensor effective in the administrative sensor of the ** and the amount of discharge of the dc-battery in an electric vehicle etc. is realized.

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CLAIMS

[Claim(s)]
[Claim 1] While carrying out penetration arrangement of the detected lead wire with which it has the following and a direct current and alternating current flow inside said dc-component detection core and an alternating current component detection core Each exiting coil which carries out winding arrangement is connected to the dc-component detection core of said couple so that it may become an opposite phase in electromagnetism. By passing the exciting current of the shape of a chopping sea which generates the magnetic field which exceeds the coercive force of this core to each dc-component detection incore While measuring the force current to the feedback coil which makes zero substantially the output of a dc-component sensing coil based on the magnetic flux to generate and the magnetic flux which generates a detected lead wire according to the flowing direct current The current sensor characterized by measuring the direct current and alternating current which flow a detected lead wire by measuring the alternating current generated in a feedback coil based on the magnetic flux which generates a detected lead wire in an annular soft magnetic material by the flowing alternating current. The dc-component detection core which consists of an annular soft magnetic material of the couple which carries out winding arrangement of the exiting coil at the shape of toroidal one The dc-component sensing coil which carries out winding arrangement ranging over the dc-component detection core of this couple The alternating current component detection core which consists of an annular soft magnetic material The feedback coil which carries out winding arrangement ranging over the dc-component detection core of said couple, and an alternating current component detection core
[Claim 2] The current sensor characterized by consisting of a configuration in which the alternating current component detection core which consists of an annular soft magnetic material carried out couple arrangement in claim 1 at the ends side of this dc-component detection core through the dc-component detection core which consists of an annular soft magnetic material of a couple.
[Claim 3] The current sensor characterized by consisting of a configuration which has arranged the dc-component sensing coil which carries out winding arrangement of the exiting coil in claim 1 ranging over the dc-component detection core which consists toroidal [-like] of an annular soft magnetic material of the couple which carries out winding arrangement, and the dc-component detection core of this couple in a shielding case.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the strabism explanatory view showing the configuration of the direct-current sensor of this invention.
[Drawing 2] The graph which shows the magnetic flux which generates A in dc-component detection incore, the graph which shows the output which generates B, C, and D in a dc-component sensing coil, and E are graphs which show the output obtained by C, D, and the dc-component sensing coil added together.
[Drawing 3] It is the graph which shows the relation between a measured current and the output current.
[Drawing 4] It is the graph which shows the relation between the frequency of a measured current, and output fluctuation, and in a, 5Arms(es) and d show 10Arms(es) and, as for 500mArms(es) and b, e shows the case of 20Arms(es), as for 1Arms and c.
[Drawing 5] The response waveform of the penetration current to which A flows to a detected lead wire, and B are graphs which show the response waveform of the output voltage of a feedback coil.
[Description of Notations]
1a, 1b Dc-component detection core
2a, 2b Exiting coil
3 Dc-Component Sensing Coil
4 Alternating Current Component Detection Core
5 Feedback Coil
10 Detected Lead Wire

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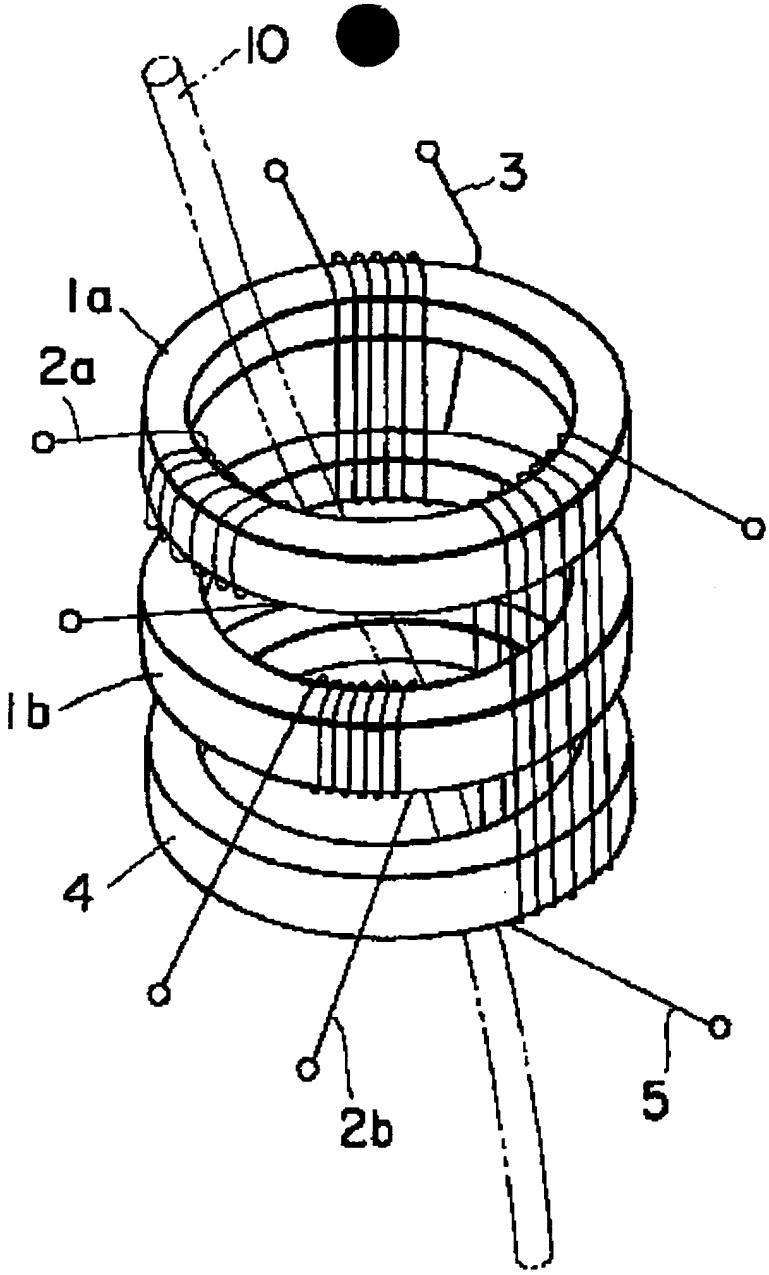
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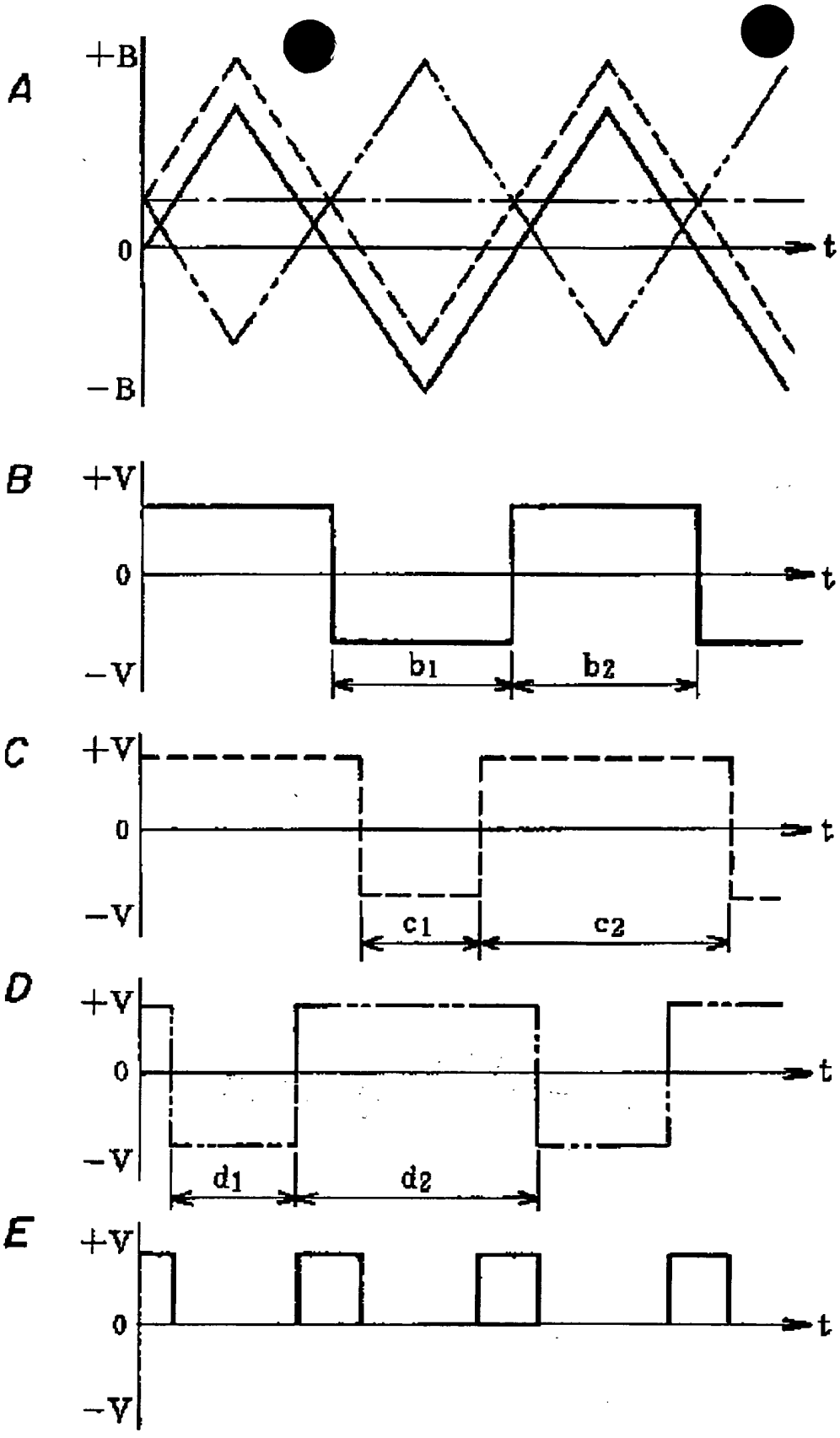
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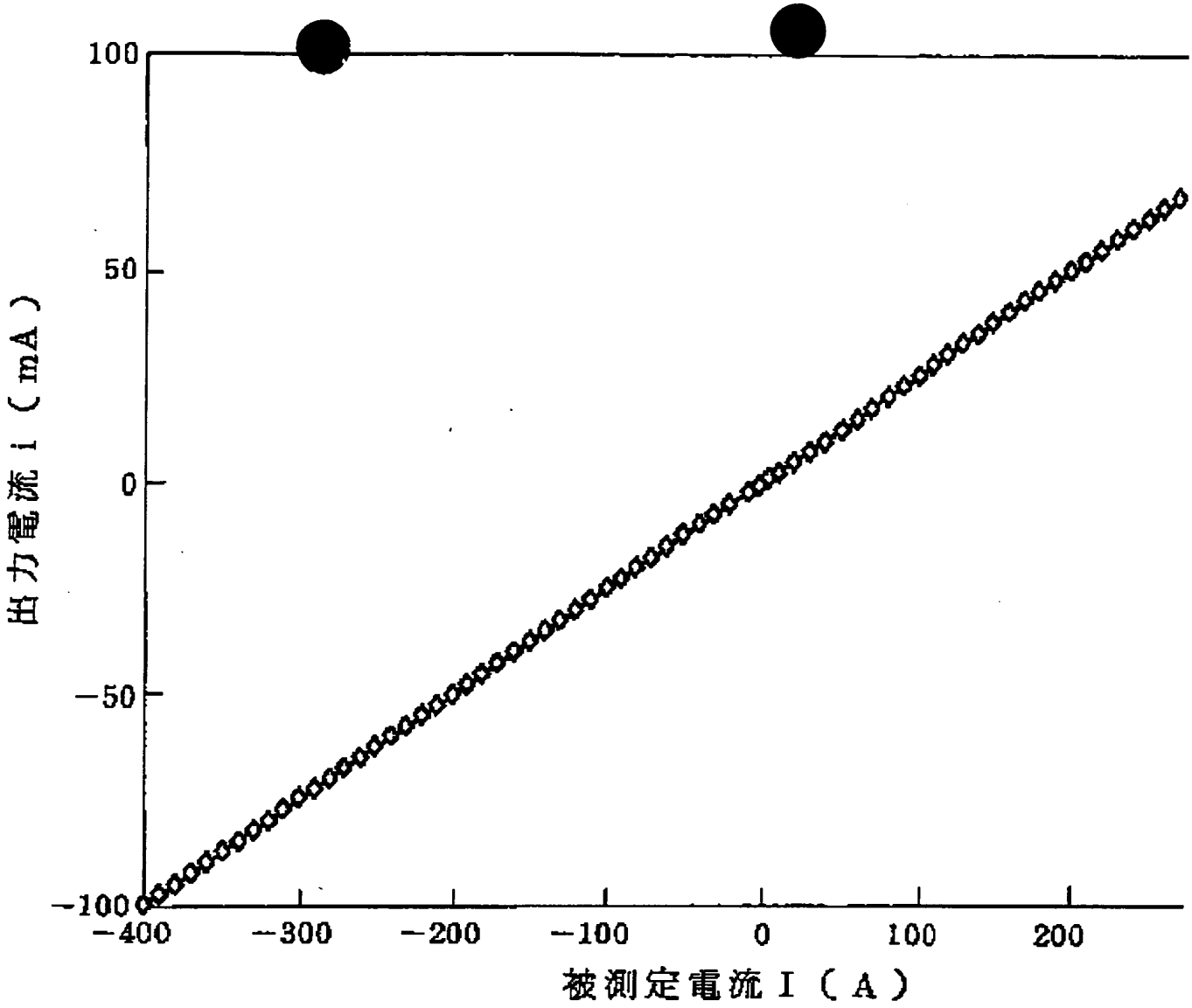
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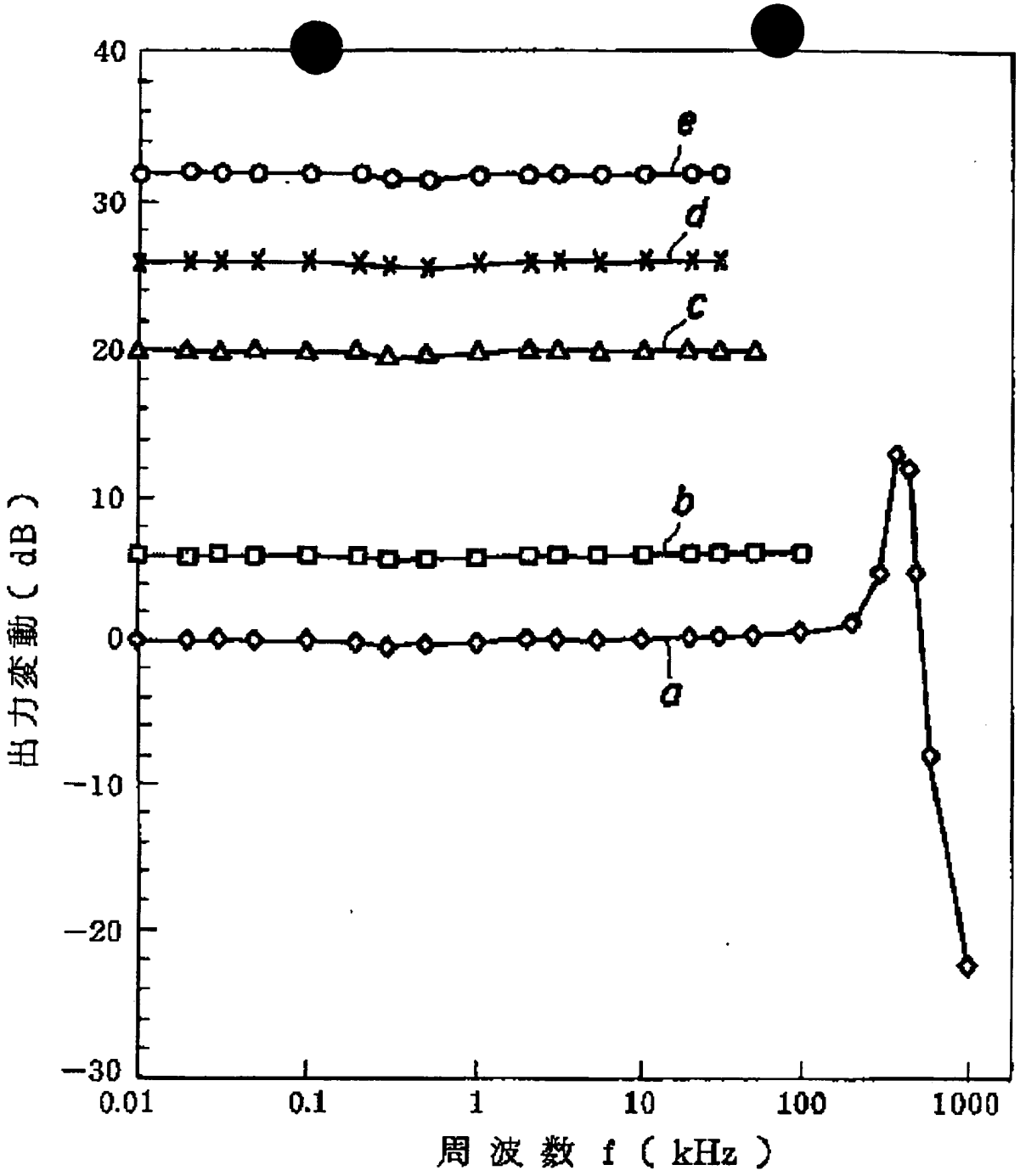
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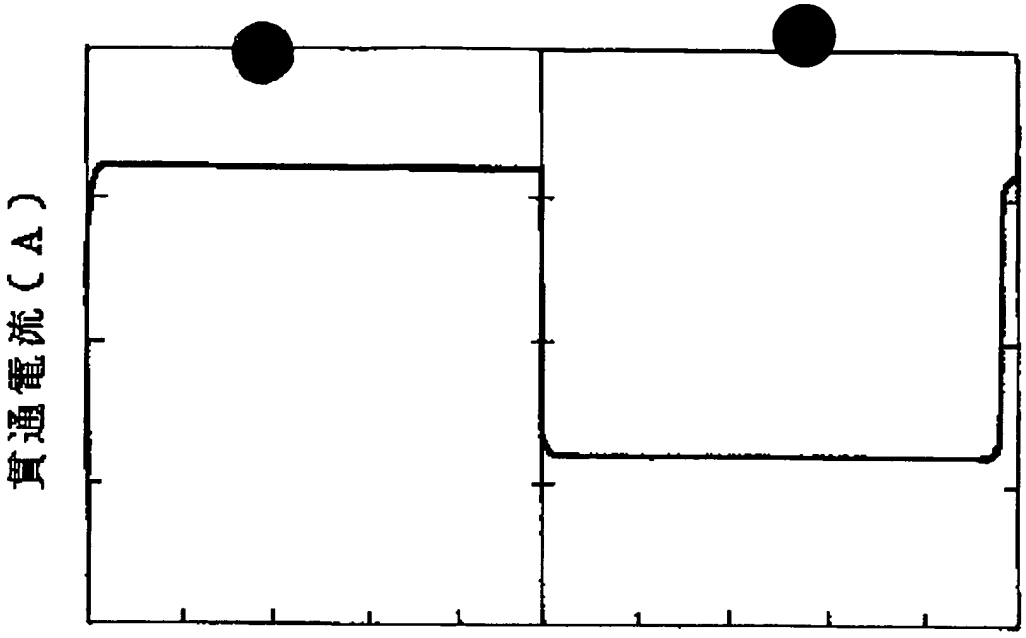

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